PRELIMINARY
INSTRUCTION MANUAL

MODEL 21
11 MHz STABILIZED
FUNCTION GENERATOR

WAVETEK

WAVETEK SAN DIEGO, INC.

9045 Balboa Ave., San Diego, CA 92123

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SAFETY

This instrument is wired for earth grounding via the facility power wiring. Do not bypass earth grounding with two wire extension cords, plug adapters, etc.

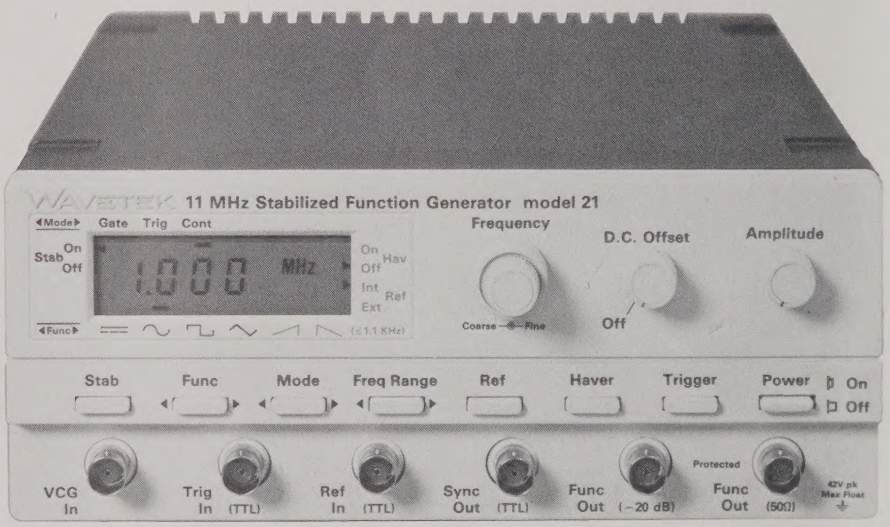
BEFORE PLUGGING IN the instrument, comply with installation instructions.

MAINTENANCE may require power on with the instrument covers removed. This should be done only by qualified personnel aware of the electrical hazards.

The instrument power receptacle is connected to the instrument safety earth terminal with a green/yellow wire. Do not alter this connection. (Reference: ⏚ or ⚠ stamped inside the rear panel near the safety earth terminal.)

WARNING notes call attention to possible injury or death hazards in subsequent operations.

CAUTION notes call attention to possible equipment damage in subsequent operations.



Model 21. 11 MHz Stabilized Function and Sweep Generator

SECTION 1
GENERAL DESCRIPTION

1.1 Model 21

Model 21 is a closed-loop, frequency stabilized, function generator. Both short term and long term frequency accuracies are 0.09% over its 100 μHz to 11 MHz frequency range.

Modes are continuous, triggered and gated. Output levels are to 20V peak-to-peak (10 Vp-p into 50Ω).

Waveforms are sine, triangle, square, ramp up, ramp down, haversine, havertriangle and dc. Above 1.1 kHz waveforms are analog generated; below, waveforms are digitally synthesized. Synthesized waveforms can be held at any point and continued from that point.

Synthesized output signal frequency is 1/1000 of reference clock frequency, which can be internal or external. By use of an external reference clock, the output range can be extended to ultra-low frequencies.

An LCD display shows frequency (3½ digits plus unit of measure) and annunciators that indicate selected operating modes, etc. Output is reverse power protected.

1.2 SPECIFICATIONS

1.2.1 Versatility

Waveforms

A bidirectional switch selects sine (∿), triangle (∿), square (⊓) and dc (⎓). For frequencies below 1.100 kHz ramp up (◿), ramp down (◺) and haverwaves(⩚ , ⩙) are also available.

Operational Modes

Continuous: Generator runs continuously at selected frequency.

Triggered: Generator is quiescent until triggered by external signal or manual trigger, then generates one complete waveform cycle at selected frequency.

Gated: As triggered mode, except output continues for duration of gate signal. Last waveform started is completed.

Frequency Range

100 μHz to 11 MHz in 9 overlapping decade ranges. Range switching with bidirectional switch with frequency digits; decimal and units displayed on LCD display. Each decade range capable of 1100:1 frequency change controlled by the Frequency Coarse and Fine controls.

Function Output

Waveform amplitude variable over a 20 dB range up to 20 Vp-p (10 Vp-p into 50Ω) at Function Out. Waveform also present at Function Out (-20 dB) with a fixed 20 dB attenuation relative to the Function Out for a full 40 dB of amplitude range. Peak output current is 100 mA maximum at Function Out. Source impedance of both outputs is 50Ω.

DC Offset and DC Output

Waveform offset and dc output variable with DC Offset control with off position for calibrated zero offset. Function Out is ± 10V maximum (± 5V into 50Ω) as offset or Vdc output. Signal peak plus offset limited to ± 10V (± 5V into 50Ω). DC offset plus waveform attenuated proportionately at Function Out (-20 dB).

Sync Output

TTL pulse (50% duty cycle) at generator frequency will drive 10 LS TTL loads.

VCG — Voltage Controlled Generator

Up to 1100:1 frequency change with external 0 to ± 5V signal applied to VCG IN connector. Upper and lower frequencies limited to maximum and minimum of selected range. Input impedance is 5kΩ and maximum slew rate is 0.1V/μs. VCG IN is disconnected when the Stabilizer is engaged.

Trigger and Gate

External TTL compatible signal at Trig In BNC triggers or gates generator output when generator is in trigger or gate mode. Generator triggers on positive edge of input or gates on for duration of high level input. External signal pulse width is 50 ns minimum with a maximum repetition rate of 5MHz.

Stabilizer

When selected, the generator frequency is stabilized at the displayed frequency to a crystal-controlled reference. The Stabilizer improves long term frequency stability for all durations to be equal to the 10 min. short term value.

When the stabilizer is on, the generator frequency is corrected to the displayed frequency ± 0.09% of range over the entire operating temperature range of 0 to + 50°C. The stabilizer is automatically turned off when the mode is taken out of continuous or Ext Ref. is enabled.

Display

1100 count LCD frequency display with frequency ranging units (mHz, Hz, kHz, and MHz) and decimal point. Annunciators indicate selection of waveform, stabilizer and external reference status, haverwave selection and generator mode.

External Reference

External Reference switch provides selection of internal or external control of waveform output frequency and also provides a means of holding or releasing the waveform manually, electrically or through external contact closure. External Reference connector accepts either a TTL compatible signal (1.1 MHz maximum repetition rate, 200 ns minimum pulse width) or contact closure. External reference provides four modes of operation.

Int Ref: Normal waveform function generator operation when in internal reference and the Ext Ref BNC is either left unconnected or connected to + 5 Vdc or a TTL high.

Ext Ref: External Reference operation by applying frequency to the Ref In BNC with external reference selected. Frequency input controls frequency of the selected waveform at the output. The output frequency will be 1/1000 the reference frequency. Maximum output frequency is 1.100 kHz. When external reference is selected, the display is disabled and blanked.

Manual Hold: At any point on the output waveform by use of the Ref button. Reference mode must be "Int Ref" as above. When Ref button is pressed, the output is stopped. When pressed again, the waveform will start again exactly where it stopped.

Electrical Hold: At any point on the output waveform:

When in "Int Ref" operation and 1.100 kHz or below, hold the waveform by applying 0 Vdc or a TTL low to the Ext Ref BNC or through remote contact closure shorting out the BNC.

When in "Ext Ref" operation, hold the waveform by removing the external signals at Ext Ref BNC or bringing it to 0 Vdc.

1.2.2 Frequency Precision

Frequency Display Accuracy

± 1 count of 1100 counts, which is 0.09% of range. Stabilizer maintains same reading indefinitely.

Time Symmetry

Square waveform variation from 1100 to 100 counts on display less than:

± 0.1% to 1.100 kHz (across bottom five specified ranges),
± 1% to 110.00 kHz,
± 5% to 11.00 MHz.

1.2.3 Amplitude Precision

Sine Variation with Frequency

Less than:

± 0.2 dB on all ranges up through the 10.0 to 110.0 kHz range,
± 1.5 dB to 11.00 MHz.

Referenced to 1 kHz.

1.2.4 Waveform Characteristics

Sine Distortion

Less than 0.5% THD up through the 1.00 to 11.00 kHz range and less than 1% THD up through the 10 to 110.0 kHz range. All harmonics 40 dB down from the fundamental across the 100 to 1100 kHz range and 28 dB across the 1.00 to 11.00 MHz range.

Triangle Linearity

Greater than 99% to 110 kHz.

Square Wave Rise and Fall Times

Less than 22 ns at Function Out with 10 Vp-p output into 50Ω.

Square Wave Total Aberrations

Each peak less than 5% of p-p amplitude

1.2.5 General

Output Protection

Function outputs are protected against a short circuit to any voltage between ± 10V dc and also have internal fused protection (both output and common conductors) against accidental application of up to 250 Vac or 350V dc.

Stability

Amplitude, Frequency (Non-Stabilized) and DC Offset: After 30 minute warm-up;

±0.10% of range for 10 minutes,
±0.50% of range for 24 hours.

Frequency (Stabilized): ±0.10% of range for ⩾10 minutes, 0 to 50°C.

Environmental

Temperature Range: 25°C ± 10°C for spec operation, operates 0°C to 50°C, −20°C to +75°C for storage.

Warm-up Time: 20 minutes for specified operation.

Altitude: Sea level to 10,000 ft for operation. Sea level to 40,000 ft for storage.

Relative Humidity: 95% at 25°C and at sea level (noncondensing).

Dimensions

21.1 cm (8.3 in.) wide, 8.6 cm (3.4 in.) high, 30.5 cm (12 in.) deep.

Weight

3.4 kg (7 1/2 lb) net, 4.5 kg (10 lb) shipping.

Power

90 to 128, 180 to 256V, 48 to 66 Hz, less than 35 VA.

NOTE

All specifications apply for display between 1100 and 100 frequency counts; amplitude at 10 Vp-p into 50Ω.

SECTION 2
INITIAL PREPARATION

2.1 UNPACKING INSPECTION

After carefully unpacking the instrument, visually inspect all external parts for possible damage. If damage is discovered, file a claim with the carrier who transported the instrument. The shipping container and packing material should be saved in case reshipment is required.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

WARNING

To preclude injury or death due to shock, the third wire earth ground must be continuous to the facility power outlet. Before connecting to the facility power outlet, examine extension cords, autotransformers, etc., between the instrument and the facility power outlet for a continuous earth ground path. The earth ground can be identified at the plug on the instrument power cord; of the three terminals, the earth ground terminal is the nonmatching shape, usually cylindrical.

CAUTION

To prevent damage to the instrument, check for proper match of line and instrument voltage and proper fuse type and rating.

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 115 Vac line supply and with a 3/8 amp fuse. If the unit is shipped for 115 Vac operation, there will be no markings or tags on the unit. If the unit is shipped for 220 Vac operation, there will be a 220 Vac tag on the rear panel of the unit.

2.2.2 Verifying the Line Voltage

CAUTION

All calibration pots are located inside the bottom cover on the circuit board. Be careful not to bump any pots, as this may require a recalibration of the instrument. Moving R103, located near the front panel, can keep the generator from operating; if adjustment is needed, refer to table 5-1 steps 1 through 10.

To verify the line voltage (or change the fuse), the operator must first remove the top and bottom covers. Remove the top and bottom using the following steps and figure 2-1.

1. Remove two (2) screws holding top and bottom covers to rear panel.
2. Slide both covers (together as a unit) to the rear and remove from the chassis assembly.

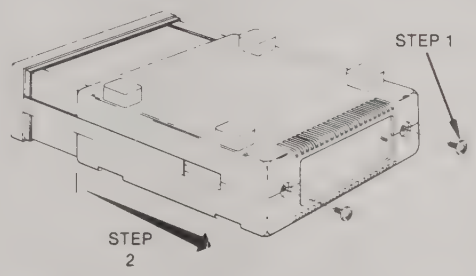


Figure 2-1. Top and Bottom Cover Removal

After the covers have been removed, the line voltage can be checked by viewing the voltage label through the inspection hole as shown in figure 2-2.

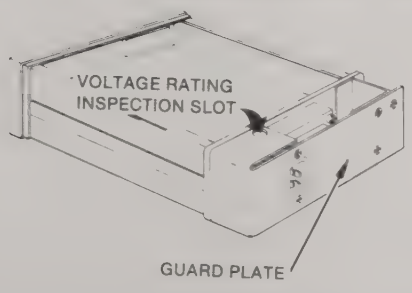


Figure 2-2. Line Voltage Inspection Hole

2.2.3 Fuse and Voltage Selection

If the line voltage is not correct, perform the following steps and refer to figure 2-3 for steps 1 and 2, and figure 2-4 for steps 3 thru 5 to change the line voltage and fuse.

1. Remove the five screws attaching the guard plate.
2. Hold the ac power receptacle assembly against the rear panel while removing the guard plate.

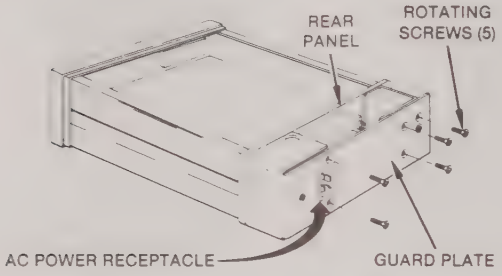


Figure 2-3. Guard Plate Removal

3. Hold the ac power receptacle firmly against the rear panel and remove the voltage selector connector from the ac primary board. Rotate the connector until the correct voltage selector indicator is on top.

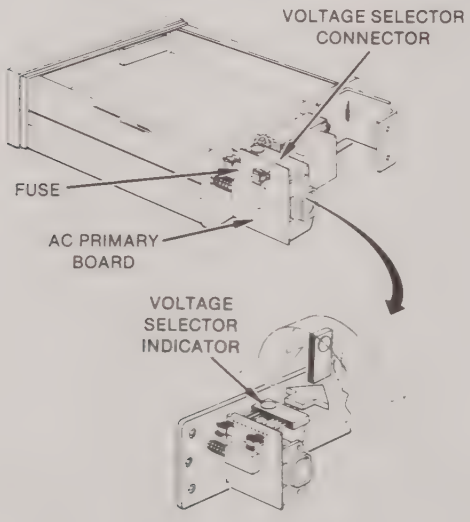


Figure 2-4. Fuse and Voltage Selection

4. Reinstall the voltage selector connector.
5. Remove the fuse and install new fuse as called out in table 2-1.

Table 2-1. Voltage/Fuse Selection

Connector Position	Voltage Range	Fuse
115V	90 to 128 Vac	3/8 amp
220V	180 to 256 Vac	3/16 amp

WARNING

Because lethal voltages are exposed, do not apply ac power to the unit until the guard plate is attached to the unit.

2.2.4 Reassembly

Refer to figure 2-5 for steps 1 thru 5 and figure 2-6 for steps 6 thru 8.

1. Ensure the power rod goes through the slot in the front panel and the ac primary board seats into the slot in the rear panel.
2. Align the guard plate to the ac power receptacle and check the routing of all wires to prevent pinching wires between the transformer and guard plate.
3. Verify that the power rod extends through the front panel slot, the circuit board seats correctly in the rear panel slot.
4. Verify the guard plate, ac power receptacle and rear panel standoffs are properly aligned and then secure with two screws.
5. Fasten the guard plate to the unit with the three remaining screws.

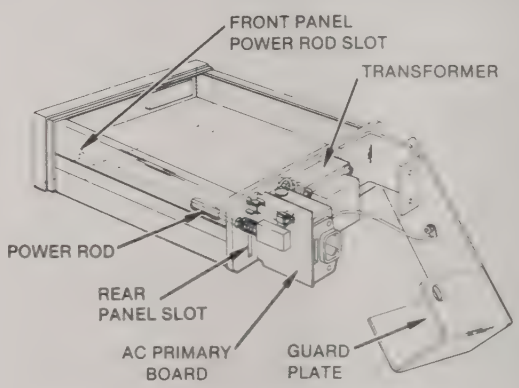


Figure 2-5. Rear Chassis Assembly

CAUTION

When sliding on the bottom cover, avoid pinching any coaxial cables located near the front panel.

6. Turn the instrument upside down, position the bottom cover over the guard shield, and then slide the bottom cover forward approximately two inches while engaging the cover and slides (see figure 2-6, detail A and detail B). Don't slide the cover on yet.
7. Turn the instrument right side up. Install the top cover using the same procedure as in step 6. Don't slide the cover on yet.
8 Align the rear of both the top and bottom cover with each other so that the cover interlocks are properly mated. Once mated, hold the covers firmly together and slide the chassis assembly into the mated top and bottom covers.
9. Secure covers to the chassis assembly using two screws as shown in figure 2-1.

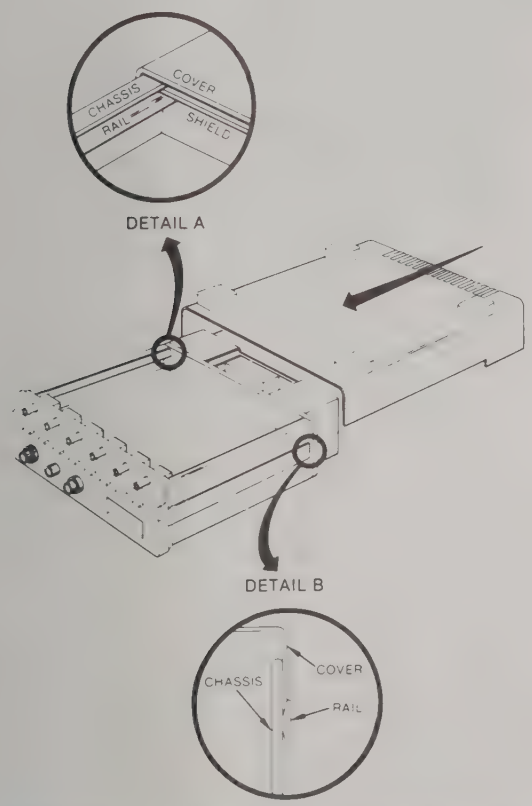


Figure 2-6. Top and Bottom Cover Installation

2.2.5 Signal Connections

Use RG58U 50Ω or equivalent 50Ω coaxial cables equipped with BNC connectors to distribute signals.

NOTE

Signal ground may be floated up to ± 42V with respect to chassis ground. Be aware that all signal grounds are common and must all be floated together.

2.3 INITIAL CHECKOUT PROCEDURE

The initial checkout procedure in table 2-2 allows the operator to learn the basic operation and capabilities of the Model 21 in an easy and orderly fashion. In addition, it can be used as a receiving inspection or post-repair checkout. While this procedure verifies functional operation of this instrument, it does not verify the calibration. **The frequencies shown are typical values and should only be used as a guide.** Required tools and test equipment are shown below.

Instrument	Comments
Oscilloscope	Dual channel, 100 MHz bandwidth
Voltage Source	+ 5Vdc
50Ω Feedthrough	0.5% accuracy, 2W
External Generator	200 Hz to 1.1 MHz TTL output
BNC Tee	1 male, 2 female connector
BNC Coax Cable	RG58U, 3 ft. length (3 each)

2.3.1 Using the Procedure

The checkout procedure (table 2-2) can be used several different ways. It can be started at step 1 and followed straight through to the final step. Or, it can be entered at the highlighted steps, which start specific groups of checks. If the table is being followed in sequence from the previous step, perform the instructions as written. But, if starting from a high lighted step, the Model 21 must be reset to the power on settings (see below). To do this, turn the Power Off, then On.

Power On status:

Frequency Range: 0.001 to 1.100 kHz
Mode: Continuous
Function: Sine
Haver: Off
Reference: Int.
Stabilizer: Off

2.3.2 Front Panel Switches

The Func, Mode, and Freq Range switches are bidirectional. To use these switches, the operator must press the left or right side of the switch's front surface, as

indicated by the arrows on the panel. Pressing the center of any bidirectional switch does not ensure correct operation. All other switches can be pressed anywhere.

When a switch is pressed, either the frequency or an annunciator on the display will change, as shown in table 2-2.

Table 2-2. Initial Checkout Procedure

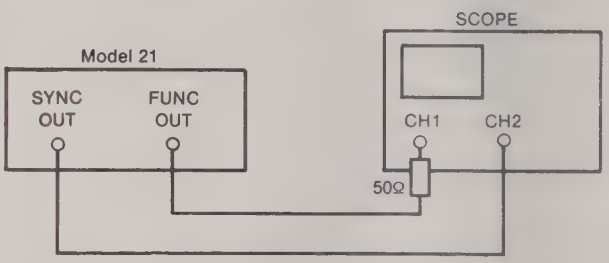
NOTE

1. *Before beginning this procedure, review paragraph 2.3.*
2. *Frequencies shown are typical and should only be used as a guide.*
3. *If starting at a highlighted step, first press Power Off, then On.*

Initial Settings

Control	Setting
Frequency	
Coarse	cw
Fine	cw
Amplitude	cw
D.C. Offset	off

Test Setup 1



Scope	Setting
Time base	0.2 ms/div
CH1 Vert	2V/div
CH2 Vert	2V/div
Trigger	CH2
Display	CH1

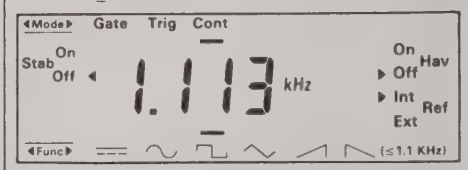
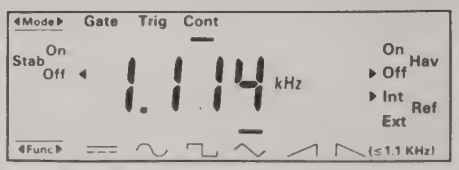
Step	Control	Operation	Display	Observation/Comments
Function Check				
1	Set to Initial Settings Power On			Connect as shown in test setup 1. 1.1 kHz, 10Vp-p sine wave.
2(a)	Func	Press Once		10Vp-p square wave
2(b)		Press Once		10Vp-p triangle

Table 2-2. Initial Checkout Procedure (Continued)

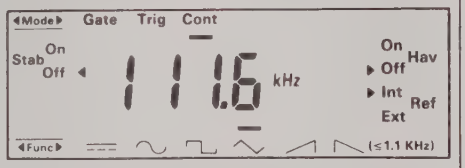
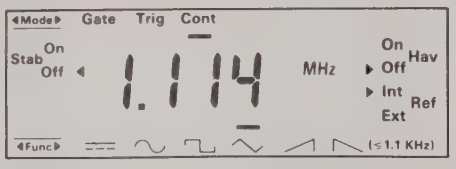
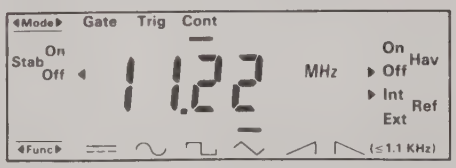
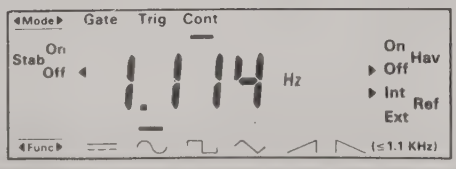
Step	Control	Operation	Display	Observation/Comments
2(c)	Func	Press Once		10Vp-p ramp down.
2(d)		Press Once		10Vp-p ramp down.
Frequency Range Check (11k to 11 MHz)				
3(a)	Freq Range	Press Once		11 kHz, 10Vp-p triangle. Ramp defaults to triangle above the 1.1 kHz range.
3(b)		Press Once		110 kHz.
3(c)		Press Once		1.1 MHz.
3(d)		Press Once		11 MHz.
Frequency Range Check (110 Hz to 110 mHz)				
4	Set to Initial Settings			Connect as shown in test setup 1. 1.1 kHz, 10Vp-p sine wave.
	Power	Press to Off then to On.		

Table 2-2. Initial Checkout Procedure (Continued)

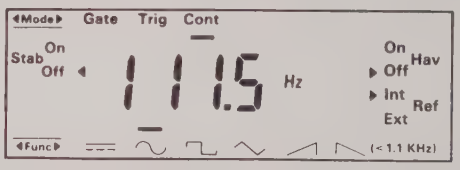
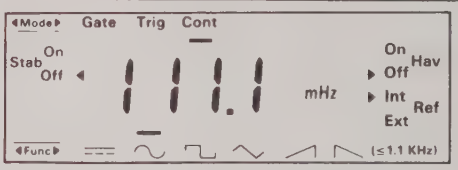
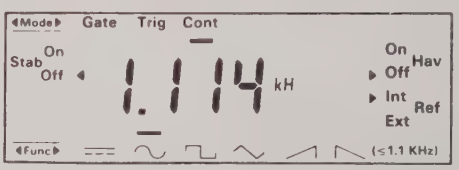
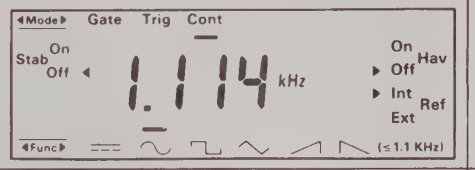
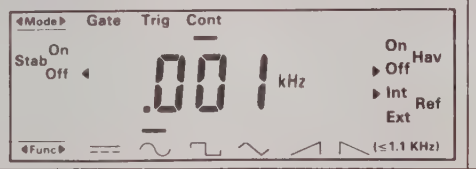
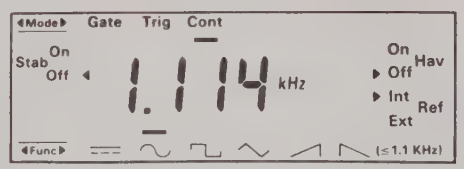
Step	Control	Operation	Display	Observation/Comments
5(a)	Freq Range	Press Once		110 Hz.
5(b)		Press Once		11 Hz.
5(c)		Press Once		1.1 Hz.
5(d)		Press Once		110 mHz.
DC Offset Check				
6	Set to Initial Settings			Connect as shown in test setup 1. 1.1 kHz, 10Vp-p sine wave.
	Power	Press to Off, then to On.		
7	Func	Press Once		0 Vdc.
8(a)	D.C. Offset	Full cw		Greater than +5 Vdc.
8(b)		OFF Full ccw, but not off		Greater than −5 Vdc.

Table 2-2. Initial Checkout Procedure (Continued)

Step	Control	Operation	Display	Observation/Comments
8(c)		OFF Off		0 Vdc
Coarse and Fine Frequency Check				
9	Set to Initial Settings			Connect as shown in test Setup 1. 1.1 kHz, 10 Vp-p sine wave.
	Func	Press Once		
10	Frequency Coarse	Full ccw		Approximately 11:1 frequency change. Verify all display segements function.
11	Frequency Fine	Full ccw		Approximately 100.1 frequency change.
12	Frequency Coarse and Fine	Both full cw		Total frequency change of 1100:1.
Amplitude Check				
13	Set to Initial Settings			Connect as shown in test setup 1. 1.1 kHz, 10Vp-p sine wave; output level decreases to 1 Vp-p as control is rotated.
	Amplitude	Rotate ccw		

Test Setup 2

Scope	Setting
Time base	0.2 ms/div
CH1 Vert	0.2V/div
CH2 Vert	2V/div
Trigger	CH2
Display	CH1

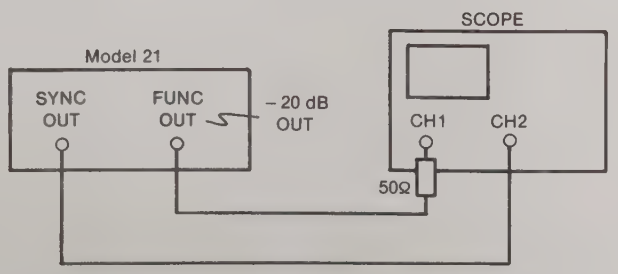
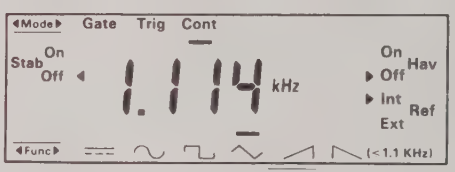
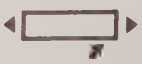
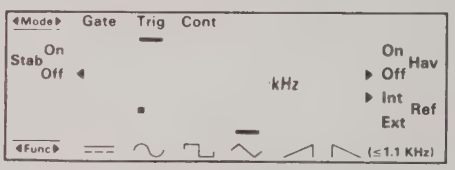
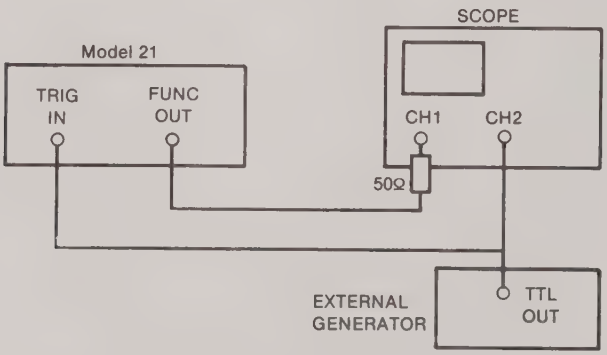


Table 2-2. Initial Checkout Procedure (Continued)

Step	Control	Operation	Display	Observation/Comments
13(b)		Rotate cw		Connect as shown in test setup 2. 1.1 kHz, 1 Vp-p triangle.
Sync Out Check				
14				Display CH2; 1.1 kHz TTL square wave.
Trigger and Gated Check				
15	Set to Initial Settings			Connect as shown in test setup 1. 1.1 kHz, 10 Vp-p triangle.
	Func	 Press Twice		
16(a)	Mode	Press Once		Approximately 0 Vdc level.

Test Setup 3



Settings	Scope
Time base	1 ms/div
CH1 Vert	2 V/div
CH2 Vert	2 V/div
Trigger	CH2
Display	CH1 and CH2

External Generator Setting
200 Hz TTL

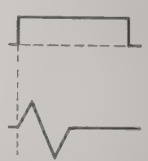
16(b)		Connect as shown in test setup 3.		CH2: Trigger Input CH1: Triggered Triangle 

Table 2-2. Initial Checkout Procedure (Continued)

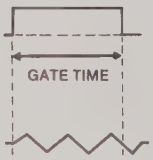
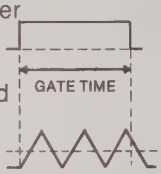
Step	Control	Operation	Display	Observation/Comments
16(c)	Mode	Press Once	Mode Gate Trig Cont; Stab On Off; kHz; On Off Hav Int Ref Ext; Func; (≤1.1 KHz)	CH1: Trigger Input CH2: Gated Triangle 
Haver Waveforms Check				
17(a)	Haver	Press Once	Mode Gate Trig Cont; Stab On Off; kHz; On Off Hav Int Ref Ext; Func; (≤1.1 KHz)	CH2: Trigger Input CH1: Gated Haver Triangle 
17(b)		Press Once	Mode Gate Trig Cont; Stab On Off; kHz; On Off Hav Int Ref Ext; Func; (≤1.1 KHz)	Disconnect external generator. Display and Trigger on CH1. Quiescent at negative peak of triangle.
Manual Trigger Check				
18	Trigger	Press and Hold		Continuous triangle while trigger button is pressed.
External Reference Check				
19	Set to Initial Settings		Mode Gate Trig Cont; Stab On Off; 1.114 kHz; On Off Hav Int Ref Ext; Func; (≤1.1 KHz)	Connect as shown in test setup 1. 1.1 kHz, 10 Vp-p sine wave.
	Power	Press to Off, then to On.		
20(a)	Ref	Press Once	Mode Gate Trig Cont; Stab On Off; kHz MHz mHz; On Off Hav Int Ref Ext; Func; (≤1.1 KHz)	Quiescent at a dc level

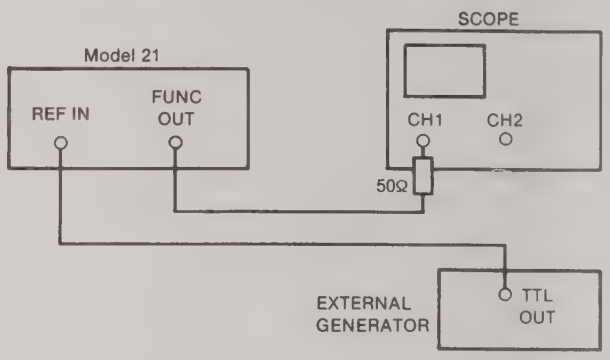
Table 2-2. Initial Checkout Procedure (Continued)

Step	Control	Operation	Display	Observation/Comments

Test Setup 4

Scope	Setting
Time base	0.1 ms/div
CH1 Vert	2V/div
Trigger	CH1
Display	CH1

External Generator Setting
1 MHz TTL



20(b)		Connect as shown in test setup 4.		1 kHz sine wave. Output frequency tracks the external generator as the frequency is lowered.
20(c)				Disconnect external generator. Quiescent at a dc level.

Stabilizer Check

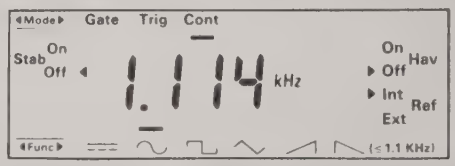
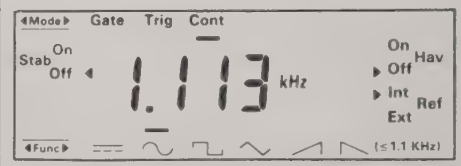
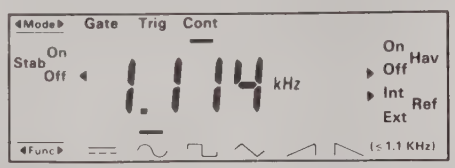
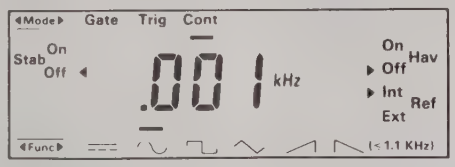
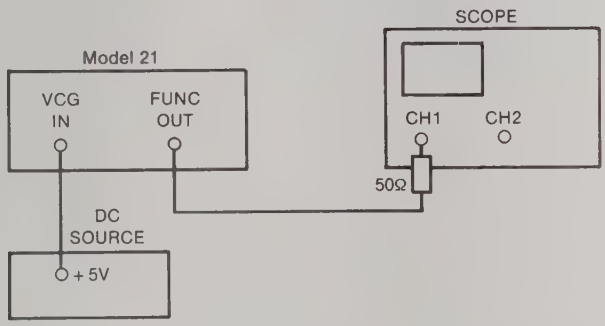
21	Set to Initial Settings			Connect as shown in test setup 1. 1.1 kHz, 10 Vp-p sine wave.
	Ref	Press Once		
22	Frequency Fine	See Comments		Rotate knob until the least significant digit fluctuates between two digits.
23	Stab	Press Once		The least significant digit remains stabilized.

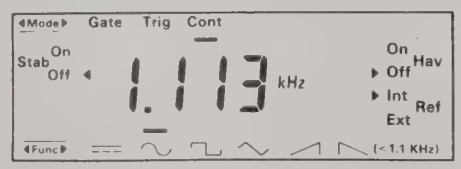
Table 2-2. Initial Checkout Procedure (Continued)

Step	Control	Operation	Display	Observation/Comments
VCG Check				
24	Set to Initial Settings			1.1 kHz, 10 Vp-p sine wave.
	Stab	Press Once		
25	Frequency Coarse and Fine	Both Full CCW		Low frequency sine wave

Test Setup 5

Scope	**Setting**
Time base	0.2 ms/div
CH1 Vert	2V/div
Display	CH1



26	VCG In	+ 5 Vdc		Connect as shown in test setup 5. 1.1 kHz, 10 Vp-p sine wave.

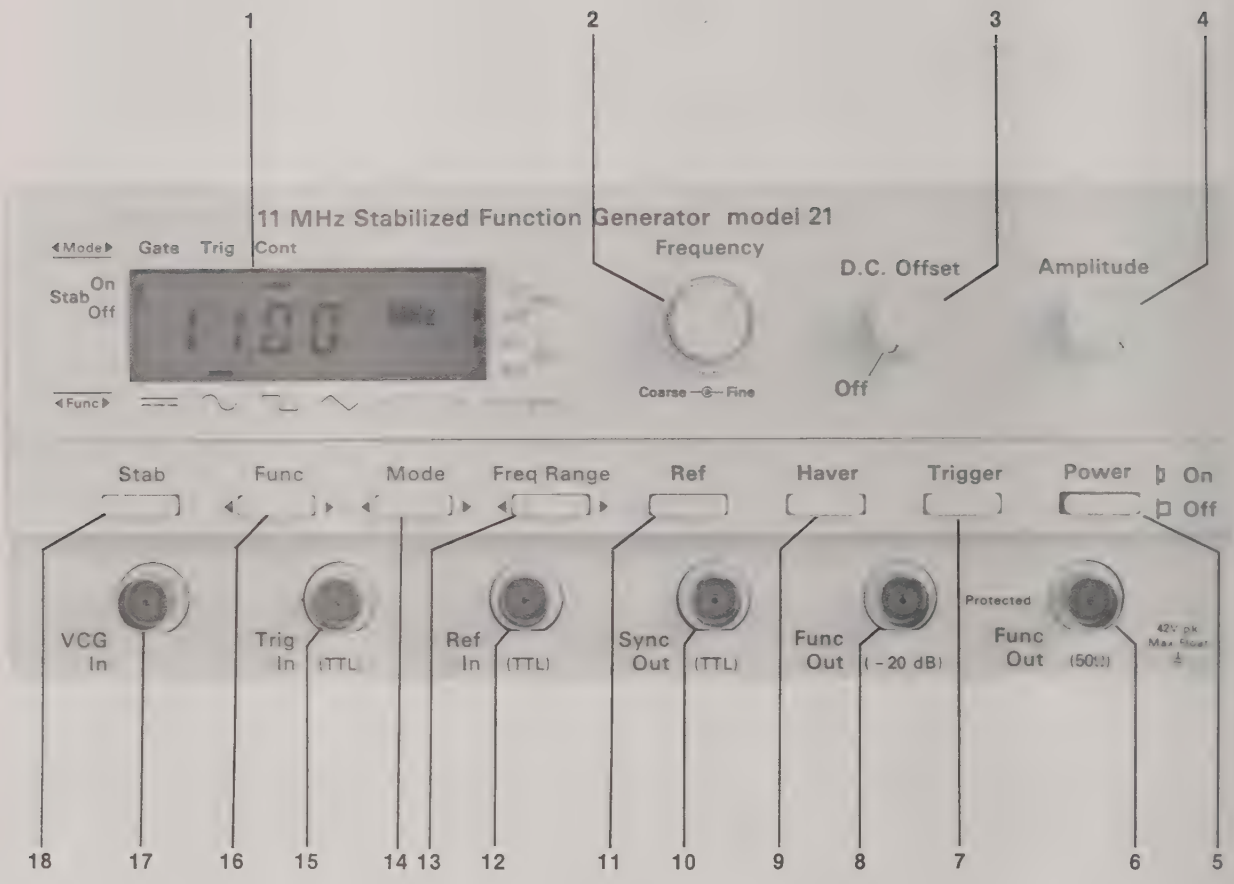


Figure 3-1. Controls and Connectors

SECTION 3
OPERATION

3.1 INTRODUCTION

This section describes the operation of the Model 21. The first part describes the controls and connectors of the instrument. The following parts describe how to use the various functions and modes of the Model 21.

3.2 CONTROLS AND CONNECTORS

The front panel controls and connectors are shown in figure 3-1 and keyed (bold numbers) to the following descriptions.

1 **Display** A 3½ digit (1100 count) LCD frequency display which incorporates annunciators that indicate mode, function (waveform), stabilizer on/off, haverwave on/off, and internal/external reference.

2 **Frequency Controls** Consist of two controls: fine and coarse. The Coarse frequency control, the outer knob of the concentric pair, allows coarse frequency adjustment (approximately 1000 counts) within the selected frequency range.

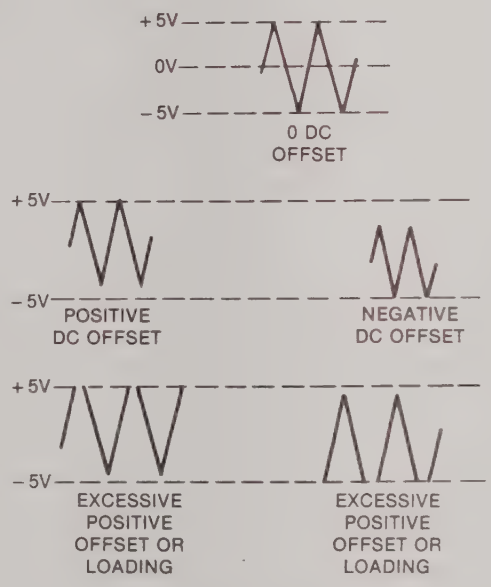
The fine frequency control, the inner knob of the concentric pair, allows fine frequency adjustment (approximately 100 counts) within the selected frequency range. Together the fine and coarse controls provide a range of 1100:1.

3 **D.C. Offset Control** This knob controls the dc voltage and offset of waveforms. A clockwise rotation vertically offsets the waveform up from the normal position (figure 3-2). A counterclockwise rotation vertically offsets the waveform down from the normal position (figure 3-2). A full counterclockwise rotation to Off ensures zero offset.

4 **Amplitude Control** This knob controls waveform amplitudes. Rotate the control full clockwise for maximum amplitude (see table 3-1). A counterclockwise rotation decreases the amplitude by 20 dB.

5 **Power Switch** The power switch turns the instrument On or Off. At power-up the instrument initializes in the following conditions:

Stab: Off
Func: Sine
Mode: Cont
Freq Range: 0.001 to 1.100 kHz
Ref: Int
Hav: Off



Function Out (50Ω) terminated with 50Ω

Figure 3-2. DC OFFSET Control

Table 3-1 Maximum Voltage at Function Out 0 dB

Function	Open Circuit	50Ω Termination
∿∿⊓	20 Vp-p	10 Vp-p
DC	±10V	±5V

6 **Function Output Connector** This BNC connector is the main output for the selected function. The Amplitude knob **4** controls the amplitude from 1 to 10 Vp-p into a 50Ω load (20 Vp-p into open circuit). Source impedance is 50Ω.

7 **Trigger Button** In triggered mode, the trigger button, when pressed, manually initiates a single cycle of waveform. In the gated mode, it gates the output until the button is released; the last gated cycle will always be completed. The quiescent output depends on the waveform selection and dc offset (see figure 3-3).

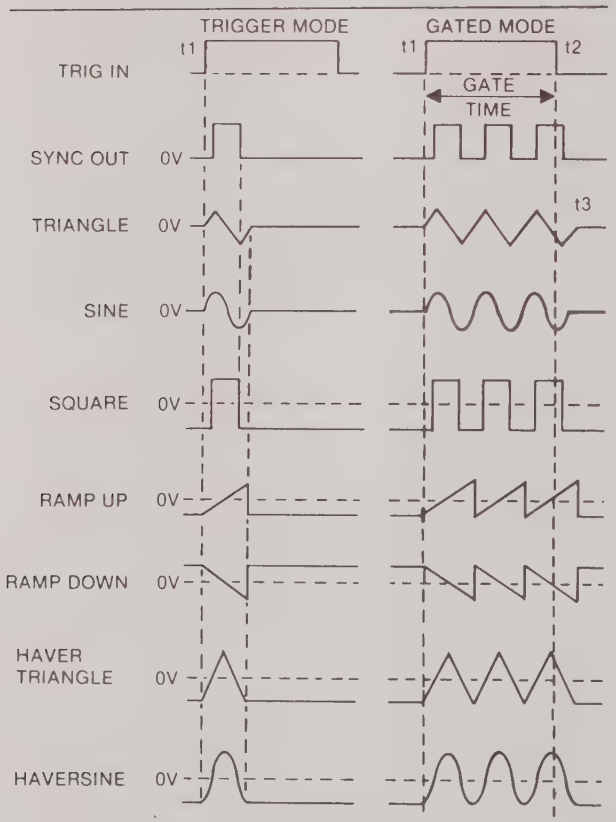


Figure 3-3. Waveforms

8 **Function Output (−20dB)** This BNC connector is the same as the Func Out **6** except the output is 1/10th (−20 dB) of the amplitude, 0.1 to 1 Vp-p. Both the waveform and offset are attenuated at Func Out (−20 dB). Source impedance is 50Ω.

9 **Haver Switch** This switch selects either the normal 0° (Haver Off) or −90° (Haver On) start/stop phase of triggered sine and triangle (figure 3-3). An annunicator on the LCD display **1** indicates the haver status. Haver wave may be selected in the trigger or gates modes using sine, triangle, and square functions on or below the 0.001 to 1.100 kHz frequency range.

10 **Sync Output** This output is a TTL square wave at the frequency of the generator. This output can be used as a synchronizing reference for the Function Outputs **6** and **8**. Phase of the waveforms relative to the sync output is shown in figure 3-3.

11 **Reference Switch** This switch serves two functions: a reference selector or manual hold control.

As a reference selector, the switch selects the reference for the waveform synthesizer, either internal or external. The annunciator on the LCD dipslay **1** indicates the reference status.

As a manual hold control with the internal reference selected and no input or TTL high at Ext Ref BNC **12**, pressing this button stops the waveform. Press the Ref button again to start the waveform.

12 **External Reference Connector** On frequency ranges below 1.100 kHz, the external reference connector serves two functions: first as an external reference input for the waveform synthesizer and second as an electrical hold for the waveform. The input functions when used with the Ref switch **11** are as follows:

External Reference Mode allows the use of an external reference signal for the synthesizer, producing a 1000 step synthesized waveform at 1.100 kHz and below. The input frequency must be 1000 times the desired output frequency; for example, 100 kHz input produces a 100 Hz output. Maximum input frequency is a 1.1 MHz TTL signal.

Manual Hold with the internal reference selected and no input or a TTL high at the Ext Ref BNC, pressing the Ref button **11** stops the waveform. Press the Ref button to again start the waveform.

Electrical Hold can be used for both internal and external reference modes. In internal reference mode, a 0Vdc, TTL low, or contact closure to ground will stop the waveform; +5V, TTL high, or an open will start the waveform from where it stopped. In external reference, removing the reference signal or supplying 0Vdc stops the waveform; applying the reference signal starts the waveform from where it stopped.

13 **Frequency Range Switch** This switch, when pushed on the left or right, steps through the nine frequency ranges as shown below.

Specified Range	Lowest Obtainable Frequency
11.00 to 1.00 MHz	0.01 MHz
1.100 to 0.100 MHz	0.001 MHz
110.0 to 10.0 kHz	0.1 kHz
11.00 to 1.00 kHz	0.01 kHz
1.100 to 0.100 kHz	0.001 kHz
110.0 to 10.0 Hz	0.1 Hz
11.00 to 1.00 Hz	0.01 Hz
1.100 to 0.100 Hz	0.001 Hz
110.0 to 10.0 mHz	0.1 mHz

The Frequency knobs **2** adjust the frequency within a range. The frequency and range is displayed on the LCD display **1**. Each range has an 1100:1 breadth.

14 **Mode Switch** This switch, when pushed on the left or right, steps through the three operating modes of the instrument.

Continuous Generator runs continuously at the selected frequency.

Triggered Generator is quiescent (quiescent level depends on waveform and offset selected, see figure 3-3) until triggered, when one complete cycle of waveform is generated.

Gated As for triggered except the waveform is continuous for the duration of the gate signal. When the signal stops, the last waveform cycle started is completed.

An annunciator on the display indicates the selected mode.

15 **Trigger In Connector** This connector accepts a positive-going TTL level input (t_1) to trigger and gate the generator, as shown in figure 3-3. A negative-going edge (t_2) ends the gated operation. When triggered, the generator produces one complete cycle for each trigger input. When gated, the generator produces continuous cycles until the gate signal (t_2) is removed; the last cycle started is always completed (t_3).

16 **Function Switch** This switch, when pushed on the left or right, steps through the six functions of the Model 21: sine ∿, triangle △, square ⊓, ramp up ◿, ramp down ◺, and dc. An annunciator on the LCD display **1** indicates the selected function. Ramps are only available on and below the 1.100 kHz range.

17 **VCG In Connector** This connector accepts 0 to ±5V ac or dc input signals, which, when summed with a level proportional to the frequency knobs setting, controls the output frequency within the selected range. Positive input levels increase the frequency, while negative inputs decrease the frequency. Frequency excursions of 1100:1 are possible by placing the Frequency knobs to full clockwise (0 to −5V) or counterclockwise (0 to +5V). Input impedance is 5kΩ and it has a slew rate of 0.1V/μs. If frequency stabilization is selected, the VCG In connector is internally disconnected.

18 **Stabilizer Switch** This switch references the generator to an internal standard which maintains the frequency within ±1 (least significant) digit. An annunciator on the LCD display **1** indicates the status of the stabilizer. The stabilizer works only in the continuous mode and with an internal reference.

3.3 OPERATION

Perform the initial checkout procedure in Section 2 for a feel of the instrument. Any questions concerning individual controls and connectors may be answered in paragraph 3.2. Bold numbers are keyed to figure 3-1. Outputs are shown in figure 3-3.

3.3.1 Signal Termination

Proper signal termination, or loading, of the generator connectors is necessary for its specified operation. For example, figure 3-4 shows proper termination of the Func Out (50Ω) connector. Placing the 50Ω terminator, or 50Ω resistance, in parallel with a higher impedance, matches the receiving instrument input impedance to the coax characteristic and generator output impedance, thereby minimizing signal reflection or power loss on the line due to impedance mismatch.

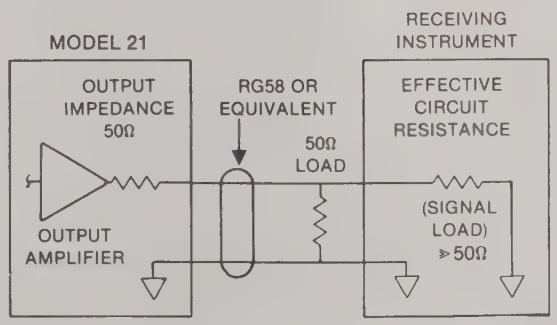


Figure 3-4. Signal Termination

The input and output impedances of the generator connectors are listed below:

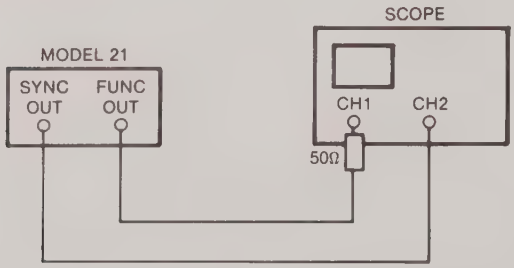
Connectors	Impedance
Func Out (50Ω) **6**	50Ω
Func Out (– 20 dB) **8**	50Ω
Sync Out **10**	TTL
Swp Out **12**	600Ω
Trig In **15**	TTL
VCG In **17**	5kΩ

3.3.2 Continuous Operation

The basic generator supplies a continuous function (waveform) at a fixed frequency set by the operator.

Control	Setting
Freq Range **13**	Set to the desired frequency range.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range.
Mode **14**	Select continuous.
D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).

To demonstrate continuous operation connect the instruments as shown below, then set the controls as listed below.



Model 21 Settings	Scope Settings
Power: On	Time base: 0.2 ms/div.
Amplitude: cw	CH1 Vert: 2V/div
D.C. Offset: Off	CH2 Vert: 2V/div.
Frequency knobs: cw	Trigger: CH2.
	Display: CH1.

Observation: The scope displays a 1.1 kHz, 10 Vp-p sine wave.

3.3.3 Voltage Controlled Generator (VCG) Operation

VCG is an external electronic means of controlling the frequency of the generator by using signal levels of up to 5V peak. This allows the generator to be swept (up or down in frequency) or frequency modulated.

Control	Setting
Freq Range **13**	Set to the desired frequency range. Frequency can only be changed within a range.
Frequency Coarse and Fine **2**	For positive dc inputs at VCG In, set the Frequency knobs to the lower frequency limit. For negative dc inputs at the VCG In, set the Frequency knobs to a higher frequency limit. For modulation with an ac input at VCG In, set the Frequency knobs at the desired center frequency
VCG In **17**	As required.
Mode **14**	Select continuous.
D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-3).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).

NOTE

Excessive VCG input voltage may cause nonlinear operation when the generator attempts to exceed the range limits.

The generator can be swept up to 1100:1 with a 5V input signal to the VCG In connector. With the frequency set to 1100, excursions between – 5 and 0V at VCG In provide a 1100:1 decreasing frequency. With the frequency set to 0000, excursions between 0V and + 5V at the VCG

In provide a 1100:1 increase frequency within the frequency range.

The VCG nomograph, figure 3-5 , gives examples of how an input voltage affects the output frequency. Example 1 shows that with 0V VCG input, the Frequency knobs determine the output frequency. Example 2 shows that a positive VCG input increases the output frequencies. Example 3 shows that a negative VCG input decreases the output frequency. In the nomograph decimal points are not shown. The output frequency must be multiplied by the range. For example, in example number 2 if the frequency range is set to the .001 to 1.100 kHz range, the display will read 0.550 kHz and when the VCG voltage is applied the display will read 1.1 kHz.

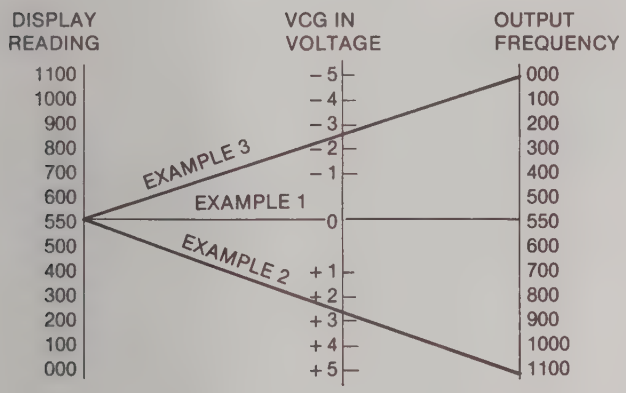
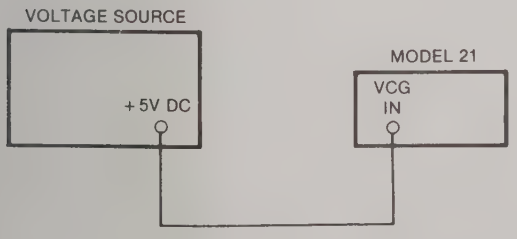


Figure 3-5. VCG Nomograph

To demonstrate VCG operation, connect the instruments as shown below, then set the controls as listed below.



Model 21 Settings	**Voltage Source Settings**
Power: On	Output level: +5Vdc.
Frequency knobs: ccw	

Observation: The display reads approximately 1.1 kHz.

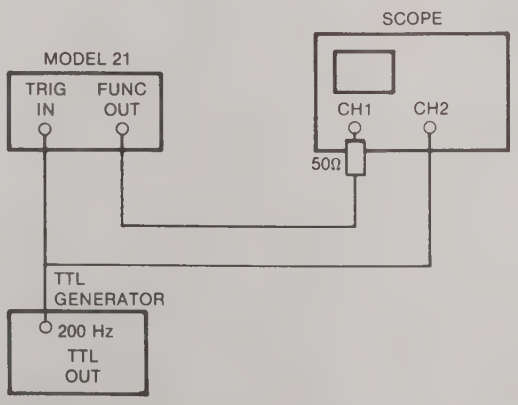
3.3.4 Triggered Operation

A triggered generator produces a single waveform each time a trigger signal is received. The Model 21 can be triggered by manual control or with a TTL signal.

Control	**Setting**
Freq Range **13**	Set to the desired frequency range.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range.
D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (−20 dB).
Func **16**	Set to desired function.
Mode **14**	Select Trigger.
Func Out (50Ω) **6** or Func Out (−20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Trig In **15**	Connect to TTL signal source at desired trigger repetition frequency (less than Model 21 frequency).
Trigger **7**	Press to trigger.

The triggered waveform starts from a quiescent point (Sine and triangle: 0Vdc; square, ramp up, haver sine, and haver triangle: lower level; ramp down: upper level. All waveforms may be d.c offset). The Model 21 triggers on the rising (⌐↑) edge of the trigger signal.

To demonstrate trigger operation, connect the instruments as shown below, then set the controls as listed below.



Model 21 Settings	Scope Settings	TTL Generator
Power: On	Time base: 1ms/div.	Frequency: 200Hz.
Frequency knobs: cw	CH1 Vert: 2V/div.	Output level: TTL.
Amplitude: cw	CH2 Vert: 2V/div.	
D.C. Offset: Off	Trigger: CH2	
Mode: Trigger	Display: CH1 and 2.	

Observation: Scope Channel 1 displays a single 1.1 kHz, 10Vp-p sine wave coincident with the rising edge of the trigger input signal (CH2).

3.3.5 Gated Operation

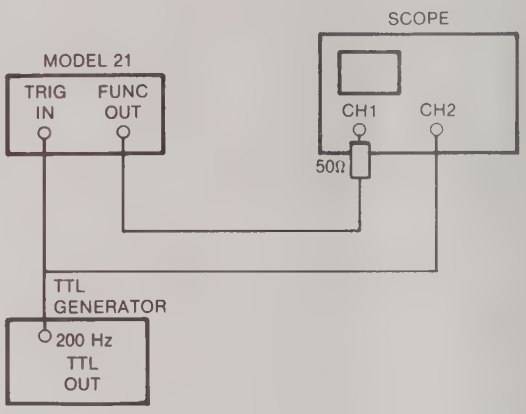
A gated generator produces a continuous output waveform for the duration of the trigger signal. The Model 21 can be gated by manual control (Trig Switch) or with an external TTL signal (Trig In).

Control	Setting
Freq Range **13**	Set to the desired frequency range.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range.
D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (−20 dB).
Mode **14**	Select Gate.
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (−20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Trig In **15**	Connect to TTL signal source at desired trigger repetition frequency (less than the generator waveform frequency).
Trig **7**	Press in to start gate; release to stop gate.

The gated waveform starts from a quiescent point (Sine and triangle: 0Vdc; square, ramp up, haver sine, and haver triangle: lower level; ramp down: upper level. All waveforms may be dc offset).

The instrument gates from the rising edge (⎍) to the falling edge (⎍) of the Trig In signal. The last cycle started will be completed.

To demonstrate gate operation, connect the instrument as shown below, then set the controls as listed below.



Model 21 Settings	Scope Settings	TTL Generator
Power: On	Time base: 1ms/div.	Frequency: 200 Hz.
Amplitude: cw	CH1 Vert: 2V/div.	Output
D.C. Offset: Off	CH2 Vert: 2V/div.	Level: TTL
Frequency knobs: cw	Trigger: CH2.	
Mode: Gate	Display: CH1 and 2	

Observation: Scope CH1 displays gated sine waves starting at the rising edge of the trigger input (CH2) and ending after the falling edge of the trigger input.

3.3.6 Stabilizer Operation

The stabilizer, when turned on, locks the frequency to the display frequency reading. Stabilizer circuit maintains the generator frequency at this setting. The stabilizer works on all frequency ranges. Thus, the frequency range can be changed without unlocking the stabilizer.

Control	Setting
Freq Range **13**	Set to the desired frequency range.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range.
Mode **14**	Select continuous.

D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Stab **18**	Select On.

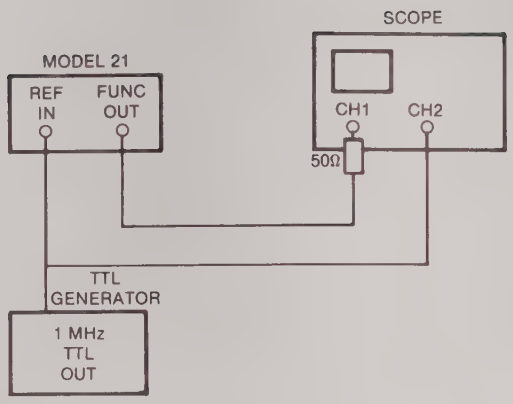
No demonstration of frequency stabilization is given.

3.3.7 External Reference Operation

When external reference is selected with an external reference signal input, the external reference signal controls the instruments frequency. The instrument frequency will be 1/1000 of the reference frequency. Maximum reference frequency is 1.1 MHz TTL signal. This produces a maximum 1.1 kHz output. There is no minimum frequency. Thus, the output frequency can be well below the minimum frequency of the Model 21.

Control	Setting
Mode **14**	Select continuous.
DC Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Ref **11**	Select Ext Ref.
Ref In **12**	Connect to external reference source. 1.1 MHz (maximum) TTL signal.

To demonstrate external reference operation, connect the instruments as shown, then set the controls as listed below.



Model 21 Settings	Scope Settings	TTL Generator
Power: On	Time base: 0.1ms/div.	Frequency: 1MHz.
Frequency knobs: cw	CH1 Vert: 2V/div.	Output level: TTL.
Amplitude: cw	Trigger: CH1	
D.C. Offset: Off	Display: CH1	
Ref: Ext		

Observation: The scope displays a 1kHz, 10Vp-p sine wave. This is 1/1000 the Ref In frequency.

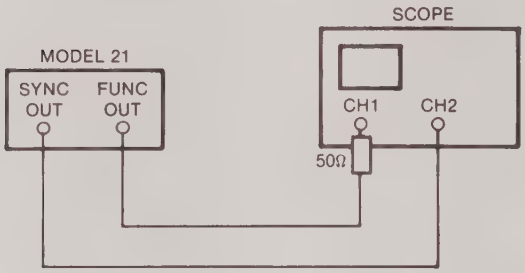
3.3.8 Manual Hold Operation

For manual hold, the Model 21 operates exactly the same as continuous except when the Ref switch **11** is pressed, the waveform immediately stops at a dc level. Pressing the Ref switch again starts the waveform.

Control	Setting
Freq Range **13**	Set to the desired frequency range.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range, 1.1 kHz or below.
Mode **14**	Select Continuous.
D.C. Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.

Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Ref In **12**	Open circuit, + 5Vdc, or TTL high.
Ref **11**	Select external reference to hold and internal reference to restart.

To demonstrate manual hold operation, connect the instruments as shown below, then set the controls.



Model 21 Settings	Scope Settings
Power: On	Time base: 0.2V/div.
Frequency knobs: cw	CH1 Vert: 2V/div.
Amplitude: cw	CH2 Vert: 2V/div.
D.C. Offset: Off	Trigger: CH2.
Ref: As directed	Display: CH1.

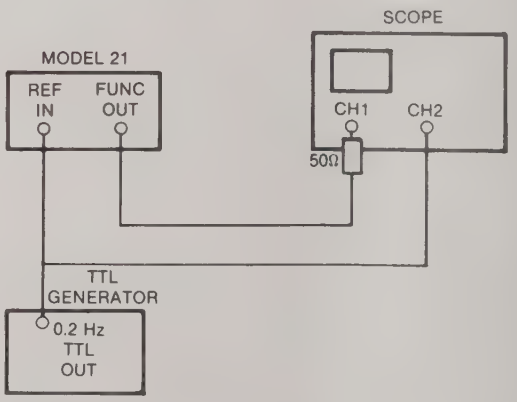
Observation: The scope displays a continuous 1.1 kHz, 10Vp-p sine wave. When the Ref switch **11** is pressed once, the waveform immediately stops at some dc level. press Ref again to resume the waveform.

3.3.9 Electrical Hold Operation

For electrical hold, the Model 21 operates exactly the same as continuous, except the output can be stopped and held at any point.

Control	Setting
Freq Range **13**	Set to the desired frequency range. Must be 1.1 kHz or below.
Frequency Coarse and Fine **2**	Set to the desired frequency within a range.
Mode **14**	Select continuous.
DC Offset **3**	Set as desired. Limit offset to prevent clipping (see figure 3-2).
Amplitude **4**	Set to desired output level at Func Out (50Ω) or Func Out (– 20 dB).
Func **16**	Set to desired function.
Func Out (50Ω) **6** or Func Out (– 20 dB) **8**	Connect to circuit under test (refer to paragraph 3.3.1).
Ref In **12**	For Int Ref operation (1.1 kHz range and below) a contact closure, TTL low, or 0Vdc holds the waveform. An open, TTL high, or + 5Vdc releases the waveform. For Ext Ref opeation, (1.1 kHz range and below) removing the reference signal or applying 0Vdc holds the waveform. Connecting the reference signal releases the waveform.
Ref **11**	Set to the desired reference source.

To demonstrate external reference operation, connect the instruments as shown, then set the controls as listed below.



Model 21 Settings	Scope Settings	TTL Generator
Power: On	Time base: 0.1ms/div.	Frequency: 0.2Hz.
Frequency knobs: cw	CH1 Vert: 2V/div.	Output level: TTL.
Amplitude: cw	Trigger: CH1	
D.C. Offset: Off	Display: CH1	

Observation: The Model 21 produces continuous 1.1 kHz, 10Vp-p sine waves when the Ref In signal is high. When the Ref In signal goes low, the output waveform is held at dc level.

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